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Improving Vertical Transport in Chemical Transport Models: Data and Model Analysis

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The goal of this start up proposal was to assess the feasibility of using field data from the Global Tropospheric Experiment (GTE) missions to provide a basis for evaluating model convective schemes in global Chemical Transport Models (CTMs) with the aim of writing a longer proposal for future work. My interest in pursuing this issue stems from a lack of global coverage of observed vertical profiles. Previous evaluations have focused on Radon which has the advantage of simple chemistry and sources[1,2]. However, there is not a broad range of regions where such observations are available. For assessing global CTMs a more diverse data set is desirable. So, although we are working with more chemically active compounds from GTE we do have a broader global coverage. As I will discuss below, the results look very promising for future work.

From the GTE data we have compiled vertical profiles from 15 distinct regions (Table 1) for carbon monoxide[3,4,5,6,7], and from the CEPEX data we have looked at ozone and relative humidity in the Central Pacific.

Table 1:

	Latitude	Longitude	Data Available
Equatorial			
Africa	20N-20S	20W-0-40E	trace
Atlantic	20N-20S	40W-20W	cite3, trace
Caribbean	15N-20N	120W-40W	cite3, able2a,b, trace
Central Pacific	20N-20S	170W-120W	cite1a, pwa
Western Pacific	20N-20S	120E-180-170W	cite1a, pwa
South America	15N-20S	80W-40W	cite3, able2a,b, trace
S. Mid-latitudes			
Africa	20S-65S	40E-10E	trace
Atlantic	20S-65S	40W-0-10E	trace
South America	20S-65S	80W-40W	trace
N. Mid-latitudes			
Asia	20N-65N	150E-0-10W	pwa
Atlantic	20N-65N	70W-10W	cite 3; able2a,2b,3a,3b
North America	20N-65N	70W-130W	cite1a,b,2,3;able2a,2b,3b;trace;pwa
Pacific	20N-65N	130W-180-150E	cite 1a, 1b, 2; pwa, able3a
North Polar			
Arctic	65N-70N	10E-0-30W	able3a
Greenland	65N-70N	30W-0-55W	able3a

Results so far confirm several characteristics in these profiles. The equatorial regions provide the most consistent information. Here, unlike the midlatitudes, we tend to find similar vertical structure day after day. In this area a dominant intrusion of air around 2-4 kilometers occurs in several regions. The most notable intrusions occur in equatorial Africa and Atlantic. An intrusion of very high concentration air is seen over equatorial Africa a little below two kilometers and is evident up to around 4 kilometers (see Figure 1). A similar intrusion occurs in the equatorial Atlantic. It begins around 1.5 kilometers lasting until 3.5 kilometers. These low-level intrusions are also evident in the Pacific from the Central Equatorial Pacific Experiment (CEPEX). While the GTE profiles and the synoptic situation suggest the cause could be a boundary layer phenomena, the CEPEX results suggest possible stratospheric influence due to high ozone and low relative humidity observed there.

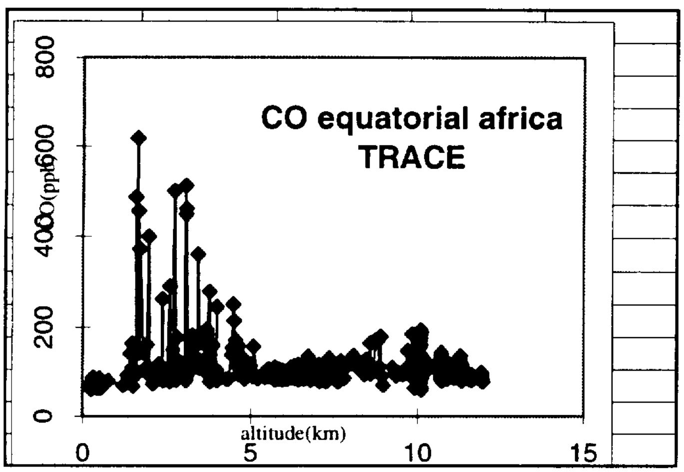

Figure 1:

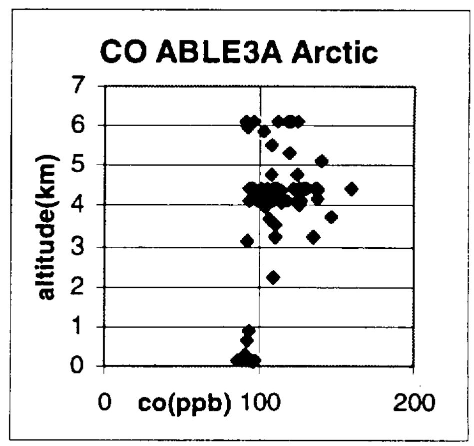

Figure 2:

Equatorial Africa contains an important result for confirming model trace gas profiles. Considering the overall and daily profiles a lull is evident at about 5-7km. The concentrations in this region are substantially less variable than the concentrations just above and below it staying right at 100 ppb CO (see Figure 1). The concentrations otherwise fluctuate by at least 50 ppb. The intrusion of high concentration ('dirty') air occurs from 2-4km, below the lull region. There the concentrations are well above normal at 300-700ppb CO.

The equatorial Central Pacific contains a wide variety of concentrations. Yet the individual profiles seem to stand out as smooth profiles. Thus, one characteristic concentration does not hold due to the variations in concentrations between longitudes but the general profiles are similar.

The mid-latitude profiles are less stable and more dependent on synoptic activity than the tropics. Two major differences include faster mixing and no strong intrusion. In mid-latitude Africa there is no lull at mid-levels as in Equatorial Africa. As is true for most of the mid-latitude profiles they are generally more homogenous but can change rapidly due to meteorological conditions. Over the Northern Pacific there is evidence of forest fire influence on the CO concentrations. This appears to play a significant role in creating high CO concentrations over the Aleutians. However, only lower altitudes are available at this location. The polar regions represent much cleaner air, but both the Arctic and Greenland profiles do have intrusions of higher concentrations in the higher altitudes(4-6km) as seen in Figure 2 below. Previous studies have attributed an increase in concentration around 4-6 km in the polar region to Arctic Haze but this is most likely due to tundra fires[5,7].

Through this work, we find there are enough observed vertical profiles that more detailed comparisons can be done to models. This work establishes a basis for a more comprehensive comparison of a model simulation to observations in many different regions around the globe. Each of the characteristics discussed above are aspects that a model should be capable of simulating. We are currently in the process of writing a paper on this work[8]. We have also developed a column model that can be used to simulate convective events as one location in a CTM would. I submitted a proposal to the MTPE/NIP/NRA in the fall of 1995 to use this model for some further preliminary analysis prior to working with a global CTM. The proposal received mixed reviews. The reviewers did have some good comments and I hope to submit another proposal in the next year which will address these issues. By that time, I will mostly likely be focusing on working with a global CTM. This will complement a new project starting up that I have proposed with some other colleagues to work with the Goddard CTM to study CO. This should give a good starting point for testing the usefulness of the CO profiles compiled in this study.

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